

Effects of a Floor on the Entrainment Flow Field Induced by a Pool Fire

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The entrainment flow field of a 7.1 cm toluene fire with a 51 cm floor has been recently (Zhou and Gore 1994a, b) studied using a laser Doppler velocimeter (LDV) and a particle imaging velocimeter (PIV). The results of these studies showed that the fire induced flow field in the presence of a floor is highly transient with root mean square (RMS) entrainment velocities having the same order of magnitude as the mean entrainment velocities. Thus instantaneous outflow (extrainment) from the visible fire surface as well as motion of the air in a direction parallel to the axis of the fire was observed. The mean velocity field showed a net inflow of ambient air into the fire surface corresponding to the air needed for the combustion process. However, the mean velocity field had no resemblance to any of the instantaneous fields. It was shown that the rate at which the ambient air is set in motion by the fire is much larger than the rate at which air enters the visible flame surface which was found to correspond closely to a location at which the vorticity increased significantly. It was found that the entrainment rate depends significantly on the definition of the size of the fire induced flow field. It was also conjectured that many of the past measurements of entrainment rate depended on the unknown definition of the flow field boundary caused by the measurement hardware such as a collection hood.

In the present work, the PIV technique was used to measure the differences between the entrainment flow field of a 7.1 cm toluene fire with and without the 51 cm diameter floor. The results show dramatic differences between the two cases. The instantaneous flow patterns surrounding the fire with the floor are shown in Fig 1a-c while those surrounding the fire without the floor are shown in Fig. 2a-c. The flow patterns without the floor show very distinct instantaneous features. Figure 1a shows strong entrainment upstream and downstream of a visible flame bulge with unique features of the flow several labeled A-E. Figure 1b shows a phase during which the air moves in a vertical direction but involves many features labeled A-D. Figure 1c shows the instantaneous extrainment phase in which the air moves away from the visible flame interface and consists a few flow features labeled A-B.

Contrary to the above, the flow field around the fire with identical burning rates and ambient conditions but without the floor is restricted to the region near the pool edge as shown in Figs. 2a-c. The flow field does not show large variations and appears to have a consistent upward and radially inward direction. The dramatic differences in the flow fields with and without the floor translate into significant differences in the entrainment rate above the fuel surface. However the overall entrainment is reduced below that of the case with floor only at axial distances above one diameter due to the entrainment occurring from below the pool surface in case of the fire without the floor.

The reasons for the dramatic instabilities caused by the floor deserve attention from both fundamental and practical view points. Fundamental questions relate to the processes driving the radial instabilities in the presence of the floor. The practical questions relate to whether the knowledge of the fire induced flow can be used in safer design of furniture size and layout.

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References

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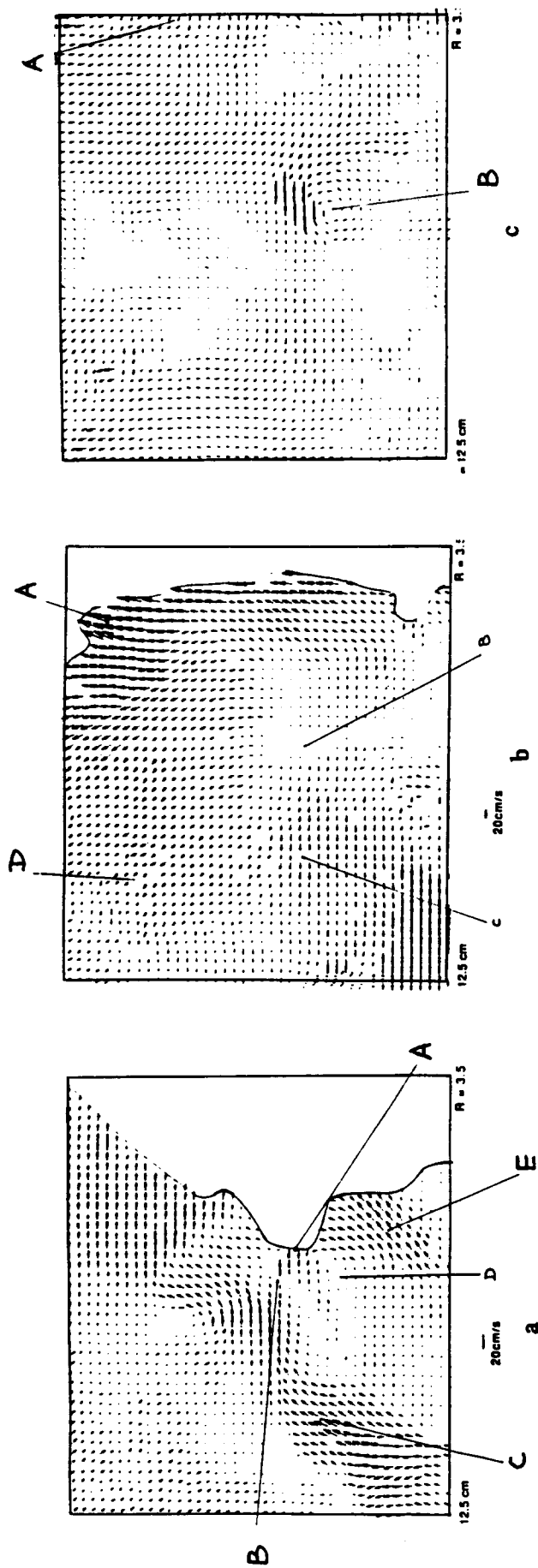


Figure 1: Flow patterns around a 7.1 cm toluene pool fire with a 51 cm floor.

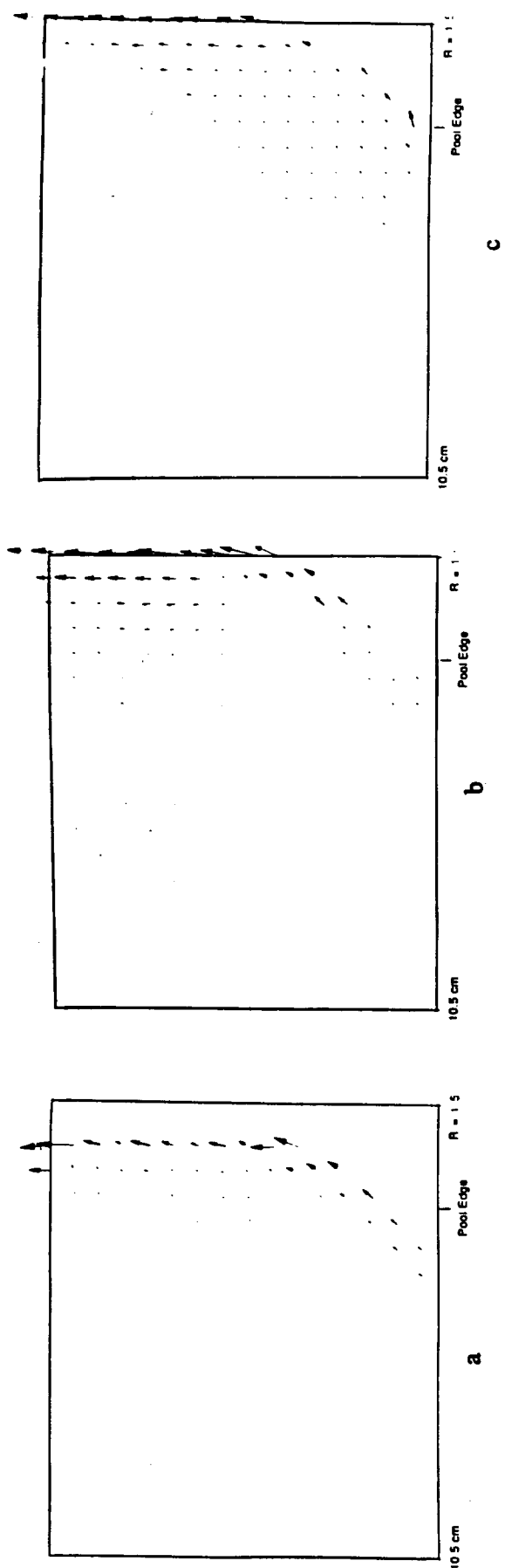


Figure 2: Flow patterns around a 7.1 cm toluene pool fire without a floor.